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Effect of Planting Depth and Control of Soil Summer Temperature on Tunic Production, Corm Propagation and Leaf Desiccation in End of Growth Period of Saffron (*Crocus sativus* L.)

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Abstract: In order to study the effect of planting depth and summer temperature control on tunic (corm fibers) production and leaf desiccating in end of growing season in Saffron (*Crocus sativus* L.) an experiment was conducted at Agricultural Research Station in Zabol University (Iran) during 2004-2005 growing seasons. The experiment was laid out in a split plot within a Randomized Complete Block Design (RCBD) with four replications. The main plots consisted of three planting depths (10, 15 and 20 cm) and three different methods for summer temperature control (control, mulching and irrigation) were arranged in subplots. The results showed leaf desiccating, corm fibers (tunic) and number of daughter corms (corms propagated) significantly decreased by increasing planting depth ($p<0.05$). In response to summer temperatures control treatments, leaf desiccating and number of daughter corms was decreased significantly ($p<0.05$), also summer temperatures control treatments had not a significant effect on tunic weight, however tunic weight decreased by mulching. Leaf desiccating, corm propagation and tunic weight significantly affected by temperature control and planting depth interaction, maximum and minimum corm propagation and leaf desiccation time were obtained at 10 cm planting depth + control and 20 cm planting depth + mulching treatment, respectively. Maximum tunic weight was obtained at 10 cm planting depth and irrigation interaction. Tunic weight decreased by increasing planting depth and summer temperatures control treatments.

Key words: Corm, tunic, leaf draying, irrigation, mulch

INTRODUCTION

Using medicinal plants as a treatment goes back to the human life's history. The human had no choice but to recourse to herbs in all eras. Although, the use of the medical and synthetic medicines increased extensively in the past 50 years, their obnoxious effects on the human life caused tendency to medicinal plants again. It is very obvious that the recourse to medicinal plants has been a good way of treatment in all history (Koocheki *et al*., 2007; Abrishami, 2004). Saffron is an important medicinal plant which its importance and application will become more overt over years. Saffron has perennial and there are different theories about its offspring. Some proofs shows that it come from Iran, from Zagros' hillsides (Kafi *et al*., 2003). Saffron as the world most expensive farming and medicinal product has a special place among Iran's other exporting goods. At present time Iran produce 65% of the world's Saffron. Besides being expensive in the worlds bazaars some cases such as its entrepreneurship, water profit comparing to other farming products and making income are some reasons why it is the focus of a special attention (Kafi *et al*., 2003). The main ground of farming activities especially Saffron is their environmental factors. It is very necessary to identify and determine each of the factors which make the ground for mentioned activities and have a direct or indirect effect on the forming of the activities. The nature of the environment combination and its potential shows the environment appropriate or inappropriate condition for Saffron plant (Rahamaty, 2003; Far, 1987). In Parker's opinion plant's growth depends on all the factors which make by environment and no single factor play a trivial role in the environment. So, identifying the factors which constitute the environment and their roles related to Saffron can help us to remove existing obstacles on the way of producing this valuable and priceless product and to provide a proper planning (Habibi and Bagheri, 1990). Continental factors, soil and its components, water resources and condition are the chief environmental constituents (Far, 1987). Flower

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completion which is the main event in the plant growth happens under the soil and the corm, main store resource for life continuance, is also formed and completed under the soil. For Saffron the soil temperature is more important than the air temperature in growing and completion. Although the soil temperature is a function of air temperature but the rate of its change in short time is less than the air temperature. In autumn the soil cools sooner than air and in spring it warms later than air (Kafi *et al*., 2003; Behnia, 1996). A lot of physiological processes of plant growth happen under the soil. In spite of seeded plants, its corm that play the role of its seed also form under the soil. Saffron's economic organ also forms and completes under the soil and just a small part of it grows in soil surface (Kafi *et al*., 2003). Plants cannot walk so they have to adjust themselves to the existing condition of soil and air. Except the coldness of perspiration, plants cannot manage the temperature of their textures very much. Plants developed some mechanisms in themselves to help them in higher temperatures; it is probable that Saffron increases the fiber on its corm under the condition of high temperature. In this study the effects of temperature on the fiber which are on the corm is investigated as well as its effects on the desiccating of the leaves that are of the important organs which affect the function. Saffron or as it called scientifically *Crocus sativus* is an Iridaceous family. Saffron is a plant by 10 to 20 cm length. Corms' diagonal is 1.5 to 5 cm, corms are intense spherical which are wide in the base. The cover of the corm is fibroid (Tunic); these fiber are thin and meshy and toward the head of the corm and reach to about 5 cm above the plants' neck (Caiola, 2004; Kafi *et al*., 2003). Saffron has two kinds of leaf; Scaly leaves and the real leaves of Saffron. Scaly leaves are white and velar and 5 to 11 pieces, they protect young leaves (Mathew, 1999; Mathew and Brighton, 1977). Real leaves are 5 to 11; they are thin and tall, without leafstalk, 1.5 to 3 mm width, dark green such as grass leaves and come out of the corm directly. Scaly leaves form tunic which covers the anatomy of the storing organ, on the corm. Tunic is a scale whose shape has changed and covers the corn in different form. Saffron has different kind of these tunics such as meshy, velar, convoluted or parallel linear yarns. This part of corm has a lot of orifices (Zargari, 1994). When Holland lily's tunic is removed from the unplanted corm, breathing will increase. This reaction is true about the other corms as well. Tunic also protects the corm against pollutions, diseases, mechanic damages (Haverkort and Kooman, 1997). Saffron's root, stem and leaves completion is from October till December. New corms produce after the blooming in November, in May the leaves turn to yellow. From May to September natal organs change but it seems that the corms are asleep (Kafi *et al*., 2003). Molina *et al*. (2005) showed that the temperature is the main and determining factor in the formation speed of the aerial organ and the flower emerge in Saffron. They found that the optimum temperature for the flower to come out of soil is less than the optimum temperature for flowering. This fact shows the discrepancies in the time of the formation of the flower in regions with different weather. Plant covering and what covers soil can affect soil temperature in two ways. First they protect soil from the sunshine and so decrease the absorption of the energy. Then what covers the soil keeps higher moisture and in this way keeps a higher temperature near the soil surface (Meriam, 1997). Plant and soil coverings and mulching absorb the sun's energy and lesson the amplitude of the soil's rippler sinus cycloid (Amirshekari *et al*., 2007). We can decrease the effects of the high temperature by lessoning the root's environment temperature using the covering of the soil as well as lessening the plant temperature by irrigation which can cause evaporative cooling through sweating. Besides increasing the amount of the soil moisture and its thermal capacity delay the change of the daily temperature and the time of arrival to a specific temperature (Azizi *et al*., 2006). The daily and seasonal temperature will change by the depth of the soil. The increasing of the soil depth will change the soil temperature as follows (Abarghouei *et al*., 2001; Zargari, 1994):

- Range of change decrease over time
- The peak of the changes delay so the higher temperatures in the deeper areas are smaller and we will reach them later in the day

The purpose of present study was to evaluate the effect of planting depth and summer temperature control on Saffron tunic production, corm propagation and leaf desiccation in end of growth period.

MATERIALS AND METHODS

The experiment was carried out during 2004-2005 growing seasons on the Agricultural Research Station farm in Zabol University, Sistan and Baluchistan Province, Iran, located in 61.31^0 longitude and 30.55^0 latitude and, 480 m Altitude from sea level. The climate was arid and warm. Experiment was conducted in split plot within a randomized complete block design with four replications. The main plots included three planting depths (10, 15 and 20 cm) and sub plot were considered three summer temperature control (check, mulching with straw in

Table 1: Soil temperature in different treatments

	Date	
Temperature (°C)	30-Jun	2-Aug
A T[1]	45.0	42.3
S T[2] without mulch	56.2	51.1
10 cm S T without mulch	46.3	41.5
15 cm S T without mulch	38.5	37.5
20 cm S T without mulch	37.5	37.0
S T with mulch	37.9	36.4
10 cm S T with mulch	37.8	35.5
15 cm S T with mulch	36.5	34.2
20 cm S T with mulch	35.5	33.5

1: Air Temperature, 2: Soil temperature

summer and one irrigation in September). The previous crop was wheat (*Triticum aestivum* L.) in 2003. The field was plowed in 30 cm depth and all plots were fertilized uniformly with decayed animal manure (30 ton ha^{-1}) and ammonium phosphate (150 kg ha^{-1}), before planting in the summer. The size of each main plot was 13.5×5 m and three subplots (4×5 m) were accommodated in them. The field was irrigated prior to planting on 10 October and corms were planted on 28 October 2004. Corms were planted in 40 cm wide rows with 15 cm spacing within-rows and also 4 corms were planted in each hole. The plots consisted of 12 rows of Saffron. First irrigation was performed after leaves grow and next irrigations were performed at required time. Weeds were controlled manually when needed. Mulching and irrigation was applied on 20 June and 20 September 2004, respectively. All studied parameters were recorded on each time. In order to evaluate the temperature changes in soil, it was measured at the 10, 15 and 20 cm depths with soil thermometer on 30 June and 2 August 2004 (Table 1). The number of propagated corms (daughter corm) was recorded in March 2005. Saffron leaves began to drying of endways in the end of growing season; dry leaf length was measured in the end of winter (with regard to the climate of location). Corm fibers (tunic) weight was measured after Saffron dry leaves from three randomly selected holes at the middle of subplot in one square meter in March 2005.

Statistical analysis was conducted using MSTAT-C software and treatment means were compared by Duncan's new multiple range test (DMRT). The probability level for determination of significance was 0.05 (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Results obtained from ANOVA showed that leaf desiccating and corm fibers cover (tunic) weight significantly affected by planting depth ($p<0.05$). Summer temperatures control treatments had a significantly affect on corm propagation and leaf desiccating, also leaf desiccating and tunic weight affected by planting depth and summer temperature control treatments interaction (Table 2).

Table 2: ANOVA of the effect of planting depth and summer temperature control on Saffron traits

SOV	df	Leaf desiccating length (cm)	corm propagation (No. h^{-1})	Tunic weight (g h^{-1})
Planting depth (A)	2	0.102*	1020.52*	0.954*
Summer temperatures Control (B)	2	0.009*	86.02*	0.050ns
A×B	4	0.009*	68.52*	0.080*
CV (%)		15.260	14.79	13.800

ns: Non significant, *p<0.05

Effect of planting depth on corm propagation: Corm propagation significantly affected by planting depth, it decreased by increasing planting depth of 10 to 20 cm ($p<0.05$), (Table 2). The results showed that corm weight in shallow surfaces planting depth was less than deep planting depth (Table 3). The corm number was increased by increasing planting depth thereupon corm weight was decreased. Corm propagation decreased in deeper planting depth, because Soil moisture and temperature increase and decrease respectively by increasing planting depth (De-Maestro and Rata, 1993).

Effect of summer temperature control on corm propagation: There were statistically different effects of temperature control on corm propagation ($p<0.05$). Corm propagation decreased by mulching due to decreasing soil temperature (Table 3, 1), it maybe due to decreased soil temperature and it fluctuations by mulching. Corm propagation increased by increment daily temperature (Yanez *et al*., 2005; Mashayekhi and Latifi, 1997).

Effect of planting depth and summer temperature control interaction on corm propagation: Planting depth-mulching interaction had a significant effect on corm propagation. Soil temperature fluctuations controlled by planting depth and mulch cover. Corm propagation limited by mulching and planting depth interaction and it decreased by mulching and deep planting depth. Maximum and minimum corm propagation was obtained at 10 cm planting depth + control and 20 cm planting depth+mulching treatments respectively (Table 4). Corm propagation decreased in deeper planting depth, because Soil moisture and temperature increase and decrease respectively by increasing planting depth (Kakhki and Hosseini, 2003).

Effect of planting depth on leaf desiccating: The result showed leaf desiccating decreased significantly by increasing planting depth ($p<0.05$) (Table 2). Leaf

Table 3: Effect of planting depth and summer temperature control on Saffron traits

	Planting depth (cm)			Summer temperatures control		
Traits	10	15	20	Check	Mulching	Irrigation
Tunic weight (g)	1.36^{a}	0.98^{b}	0.81^{b}	1.10	0.98	1.07
Leaf desiccating length (cm)	0.40^{b}	0.27^{ab}	0.22^{b}	0.32^{a}	0.27^{b}	0.30^{ab}
corm propagation (No. h^{-1})	41.00^{b}	28.20^{b}	23.80^{c}	32.80^{a}	27.70^{b}	31.70^{a}

Row means followed by the same letter are not significantly different at 0.05 probability level

Table 4: Effect of planting depth-summer temperatures control interaction on Saffron traits

	Planting depth (cm)								
	10			15			20		
Traits	Control	Mulching	Irrigation	Control	Mulching	Irrigation	Control	Mulching	Irrigation
Tunic weight (g)	1.45^{a}	1.12^{b}	1.52^{a}	0.97^{bc}	1.00^{bc}	0.97^{bc}	0.90^{bcd}	0.82^{cd}	0.72^{d}
Leaf desiccating length (cm)	0.44^{a}	0.31^{b}	0.43^{a}	0.28^{b}	0.28^{b}	0.26^{bc}	0.25^{bc}	0.21^{c}	0.21^{c}
corm propagation (No. h^{-1})	45.70^{a}	32.70^{b}	44.50^{a}	28.70^{bc}	28.70^{bc}	27.20^{bc}	25.20^{bc}	21.70^{c}	22.20^{c}

Row means followed by the same letter are not significantly different at 0.05 probability level

desiccating time delayed in deeper planting depth, because corm weight and size increased by increasing planting depth thereupon this corm produced large and strong leaf that had a high resistance against environment condition (Molina *et al*., 2005).

Effect of summer temperature control on leaf desiccating length: Summer temperature control treatments had a significantly influence on leaf desiccating ($p<0.05$), (Table 2). Leaf desiccating decreased by mulching and irrigation treatments (Table 1, 3). Soil temperature decreased by mulching in summer, thereupon corms weight increased, that those produced large leaves with high photosynthesis efficiency and high resistance against end growing season condition (Molina *et al*., 2005; Waithaka and Wanjao, 1982).

Effect of planting depth and summer temperature control interaction on leaf desiccating length: Planting depth-mulching interaction had a significant effect on leaf desiccating length (Table 1). Maximum and minimum leaf dry length were obtained in 10 cm planting depth-control and 20 cm planting depth-mulching interaction respectively (Table 4). Leaves were strong and sustain in deeper planting depth. Corm propagation and narrow leaves number increased in surfacing planting depth. Narrow leaves had low resistance against end season growing temperature condition (in winter) (Molina *et al*., 2005; Negbi, 1999).

Effect of planting depth on tunic weight: Results obtained from ANOVA has shown that tunic weight decreased by increasing planting depth ($p<0.05$) (Table 1). Maximum tunic weight was obtained in 10 cm planting depth; tunic weight in 15 cm was more than of 20 cm planting depth but this increase was not significant (Table 2). Tunic has a conservation role of corm in environment condition. Tunic increased by increasing leaves number in top planting depth (Meriam, 1997).

Effect of summer temperature control on tunic weight: However result showed that tunic weight decreased by mulching, but summer temperature control treatments did not show significant effect on tunic weight (Table 1).

Effect of planting depth and summer temperature control interaction on tunic weight: On the basis of results in Table 1 effect of summer temperature control-planting depth interaction statistically were significant ($p<0.05$). Maximum and minimum tunic weight was obtained in 10 cm planting depth-irrigation and 20 cm planting depth-mulching interaction respectively (Table 4).

DISCUSSION

Corm plays the role of the seed for Saffron. Food store, increasing the size and the weight of the corm are main factor of the function and production. Weight and size of corm are under the effects of the environmental condition. One of the environmental factors which influence corm a lot is temperature. In shallow surfaces the number of leaves increase because of the raise of the temperature; leaves end to tunic, so the amount of tunic will increase as well. It is probable that this happens to repel the increase of the temperature and the decrease of breathing in corms. In shallow surfaces increasing the number of leaves produce small leaves which cannot bear low temperature condition of the growth period and desiccate easily. Leaves fast desiccation at the end of each growth period lessen the photosynthesis efficiency and shorten the growth time.

CONCLUSION

Results of the present experiment indicated that, tunic weight decreased by summer temperatures control and planting depth treatments, also minimum leaf draying time were obtained in 20 cm planting depth and mulching. However summer temperature control and planting depth increased the leaf desiccation time, but tunic weight decreased by temperature control treatments and planting depth.

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